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(54) METHOD FOR MOULDING RESIN BONDED HIGH FRICTION MATERIALS

(71) We, PENNWALT CORPORATION, a corporation duly organised and existing under the laws of the State of Pennsylvania, United States of America, of Pennwalt Building, Three Parkway, Philadelphia, Pennsylvania 19102, United States of America, do hereby d clare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method for moulding dry, high bulk, friction materials into rigid structures such as brake shoes, brake pads and brake blocks.

In the manufacture of moulded heat dissipating, friction pads such as brake shoes, brake pads and brake blocks, extensive use is made of asbestos fibre which is admixed with a suitable synthetic resin binder to provide a dry mouldable mixture which can be subsequently compression moulded into the desired shape.

Such mixtures, however, give rise to numerous and quite serious processing problems. For example, the high bulk of the asbestos or other fibre makes it difficult to meter accurately measured quantities of the moulding powder into the compression mould. Also the handling of dry moulding formulations comprising asbestos fibre is extremely hazardous from the point of view of the health of persons operating the moulding equipment so much so that stringent regulations are in force in most countries to govern the handling of asbestos fibre and asbestos fibre products.

Various techniques have been proposed for the manufacture of resin-bonded asbestos fibre brake pads and brake linings, dealing both with the problem of handling or accurately metering quantities of the high bulk mouldable powder containing a resin binder and asbestos or other fibre, and with the safety aspects. Amongst numerous prior proposals particular mention may be made of our previous U.S. Patent Specifications Nos. 3,278,992, 3,225,963, 3,661,485 and 3,741,699.

The present invention seeks to provide an improved method of moulding resin-bonded asbestos or other fibre articles and seeks to provide improved process control and improved safety in the handling of the dry mouldable powder.

In accordance with this invention there is provided a method of producing moulded brake pads and other articles comprising a heat dissipating friction material embedded in a thermostat resin binder, which comprises:

(i) premixing the friction material in a dry state with a thermosetting resin to form a dry, mouldable mixture;

(ii) mechanically conveying the premixed materials along a first enclosed path into an enclosed hopper;

(iii) feeding the premixed materials along a second enclosed path from said hopper into a plasticizing screw of a preform moulding machine;

(iv) delivering the mixture partially plasticized by said screw, into one or a succession of preform moulds;

(v) severing each preform from the remainder of the partially plasticized material; and

(vi) compression moulding the preforms to the desired shape.

The method of this invention will be further described with reference to the accompanying drawings, in which:

Figure 1 is a side view of the preferred embodiment of the apparatus used in carrying out the method of the present invention.

Figure 2 is an enlarged isometric view of a rotatable horizontal shaft removed from the agitator portion of the apparatus of Figure 1.

Figure 3 is an enlarged, vertical side sectional view of the agitator portion of the apparatus of Figure 1, with internal parts shown in elevation.

Figure 4 is a vertical sectional view of the agitator portion of the apparatus of Figure 1, taken along the line 4—4 of Figure 3.

Figure 5 is another vertical sectional view of the agitator portion of the apparatus of Figure 1, taken along the line 5—5 in Figure 3.

Figure 6 is a schematic diagram of the electrical circuit portion of the apparatus of Figure 1.

Referring to Figure 1, there is shown a preferred apparatus used in carrying out a method according to the present invention. A bulk storage vessel 20 containing the friction material recipe i.e. binder plus asbestos or other fibre, preferably already premixed, is mounted above an agitator 10 for release thereinto of the mouldable mixture. Hereinafter this dry, mouldable mixture of synthetic resin binder and asbestos fibre is referred to simply as "the friction material". Agitator 10 is connected to feed hopper 48 of a stuffer assembly indicated generally at 12 by a flexible feed means 22 through which the agitated friction material may be transferred to feed hopper 48. Feed hopper 48 is mounted above an injection assembly indicated generally at 14 for delivery of the mouldable mixture thereinto. Injection assembly 14 has preforming means 16 at the downstream end thereof for the receipt of partially plasticized friction material. Preformer 16 operates to shape and isolate individual preforms of the partially plasticized mixture, the preforms then being passed to a compression moulding press 18 for moulding into the final product.

Bulk storage vessel 20 can be of any suitable form, for example it can be a mixing container as used for mixing the friction material at a remote station, or it can be merely a transport container used to transport the mixed friction material from a remote mixing station to the agitator 10. Container 20 is mounted on top of agitator 10 for direct and closed transfer of friction material into agitator 10, without release of any dust or fine particulate matter from the friction material into the atmosphere. Vessel 20 is retained on agitator 10 as required by any suitable connecting means. Sealing means 26 are provided at the juncture of vessel 20 and agitator 10 in order to assure that no dust or fine particulate friction material escapes into the atmosphere during transfer of the mixture from vessel 20 to the agitator 10. A suitabl cover (not shown) may b used in place of sealing m ans 26 to close the open top of the agitator when the vessel 20 is removed.

Agitator 10 has disposed therewithin a horizontal shaft 28 which has a plurality of fingers 30 extending radially and perpendicularly therefrom. Horizontal shaft 28 is driven by motor 32, which is preferably an electric motor, through gear reduction means enclosed within housing 36. In Figure 1, the outer housing of agitator 10 has been broken away to show horizontal shaft 28 and several of the attached fingers 30. Agitator 10 has extending downwardly therefrom a duct 38 for guiding the mixed and agitated friction material contained in the agitator 10 into a flexible feed conveyor 22. Flexible conveyor 22 has therein a flexible, continuous screw 40 of the auger type which is driven by a hydraulic motor 42 mounted at the end of the conveyor remote from agitator 10. It is to be understood that hydraulic motor 42 could equally well be mounted at the other end adjacent the agitator 10. Hydraulic motor 42 is mounted on a mounting bracket 43 on the hopper 48. Bracket 43, in addition to supporting hydraulic motor 42, is constructed in such a way that it encloses the upper end of feed conveyor 22. A cover 47 covers the top of feed hopper 48 so that no friction material can escape to the air as it drops into hopper 48 from the conveyor. Feed hopper 48 has been partially broken away in Figure 1 in order to show a plunger 44 secured to the lower end of an upright, vertical shaft 46 for unitary motion therewith. The plunger 44 and the shaft 46 reciprocate vertically, thereby serving to stuff friction material in the downwardly tapered feed hopper 48 through an orifice 49 at the lower end thereof into contact with rotatable plasticizing screw 52. The plunger 44 and the shaft 46 are driven by an air cylinder 76 located above hopper 48.

The plasticizing portion of the apparatus has been designated generally by arrow B and comprises plasticizing screw 52 mounted for rotational motion within plasticizing screw housing 54. Plasticizing screw 52 is driven by a hydraulic motor 50. The screw 52, housing 54 and motor 50 constitute the injection assembly 14 which is mounted on a bed plate 68. Such an assembly is described in greater detail in U.S. Patent No. 3,661,485.

At least one preform cup 70 is movably disposed at the end of plasticizing screw 52 for receipt of partially plasticized material from an orifice at the end of plasticizing scr w housing 54. An air cylinder 72 is disposed above the juncture of cup 70 and

housing 54. A housing 74 encloses a guillotine knife (not shown) which is driv n by the air cylinder 72 from its retracted position downwardly to a position between the preform cup and the plasticizing screw housing. This assembly is referred to as the preforming section and is described in more detail in said U.S. Patent No, 3,661,485.

From the preforming section the preforms are fed in a manner described in said U.S. Patent 3,661,485 to a moulding press 18. The press 18 has a base 56 upon which stationary platen 58 is mounted. Disposed above stationary platen 58 on connection guide posts 62 is a movable plat n 60. Mould halves, which are not shown, are disposed on the two platens. It is in the mould cavities defined by these mould halves that the rigid friction material bodies are formed when preforms of friction material are placed into the respective mould cavities, the mould halves are brought together, and heat and pressure are applied. Duct 64 is provided, preferably adjustably affixed to one of guide posts 62, for transferring the moulded rigid friction material bodies away from the press once moulding is complete. A hydraulic cylinder contained in hydraulic cylinder enclosure 66 provides for vertical movement of movable platen 60. Fuller details of the press 18 may be found in U.S. Patent No. 3,741,699.

Extending upwardly in a vertical direction from a reciprocable piston contained in air cylinder 76, is a rod 78, which has selectively adjustable upper and lower cams 82 and 80 affixed thereto for movement therewith. Upper cam 82 actuates an upper limit switch L4, while low r cam 80 actuates a lower limit switch L3. Upper and lower limit switches L4 and L3 are momentarily actuated while engaged by their respective, associated cams during reciprocation of rod 78.

Reference is now made to Figures 2 and 3 wherein the horizontal shaft 28 of the agitator 10 is shown with a plurality of fingers 30, 30a, 30b and 30c, protruding therefrom in a radial direction, and with a strip 31 helically formed about and affixed to the xtremities of fingers 30c. Within the agitator 10 the horizontal shaft 28 rotates in the direction shown by arrow E. The radially extending fingers 30a and radially extending finger 30b serve to continuously agitat and mix the friction material in agitator 10. The fingers 30c, are each of different length and are arranged in order of decreasing length as one moves in the axial direction denoted by arrow F. Due to the helical shape of the strip 31, as horizontal shaft 28 is rotated through the friction material present in agitator 10, friction material in the neighbourhood H of the helical strip 31 will be urged in the direction denoted by arrow F. Friction material remote from the helical strip and in the region of the fingers 30a, will then move in the direction denoted by arrow F, to fill the void left by the material which has dropped through duct 38 into the inlet 39 of the conveyor 22.

The lower end of conveyor 22 is closed by an end plate 41 so that no dust or friction material can escape therefrom. Along the length of the shaft 28 denoted by bracket G, fingers 30a serve to agitate the friction material and maintain it in a light, homogeneous condition. Along the length denoted by bracket H, the finger 30b, which is longer than fingers 30a, and the fingers 30c serve to drawn friction material from the agitator 10 into the lower end of the conveyor 22.

Reference is now made to Figure 4, wherein there is shown an end view of the shaft 28 with six equal length fingers 30a extending radially therefrom. It should be noted that the fingers 30a are closely spaced to the wall of agitator 10 to maintain substantially all the friction material in agitator 10 in an agitated, fluffed, homogeneous state. The direction of rotation of horizontal shaft 28 is denoted by arrow E″.

Reference is now made to Figure 5 which is another sectional view taken through agitator 10 showing the shaft 28 and the fingers 30c to the ends of which are secured the helical strip 31. In Figure 5, the direction of rotation of shaft 28 is shown by arrow E‴. As shaft 28 rotates in the direction shown, a corkscrew-type action by helical strip 31 will result in the friction material gathering together at the forward end of the shaft, i.e. to the right as shown in Figures 1 and 3. Due to this action and the force of gravity the friction material will fall downward into the conveyor 22 which carries the friction material along a closed path from the agitator 10 to the feed hopper 48.

Reference is now made to Figure 6 which is a diagram of electrical circuitry which controls the feeding of friction material from the agitator 10 into the feed hopper 48. The lines designated P1 and COMMON are the main electrical power lines. Switch L5 controls motor 32 and provides an electrical interlock whereby when agitator 10 is open, no mixing of friction material can take place. Line P2 provides power to the circuit elements when the apparatus of the present invention is feeding friction material in an automatic mode, to be described b low. Line P2 is connected in parallel with electrical circuitry controlling plasticizing screw hydraulic drive motor 50

so that automatic feeding of friction material cannot occur unl ss plasticizing screw 52 is rotating. Line P3 provides power for operating portions of the present invention to feed friction material. in a manual operating mode. Power to line P3 is controlled by a manual switch not shown in the diagram.

Element 92 is a material level sensing switch in feed hopper 48. Upper and lower limit switches L1 and L2 are mechanically tied and are actuated by the presence of friction material in the feed hopper 48. S1a is a pair of normally open contact points actuated by relay R1 while S3a is a pair of normally open contact points actuated by a time delay relay TDR2; S1a and S3a provide a holding circuit for TDR2. TDR2 is an "off time delay relay", when TDR2 is energised, it immediately opens normally closed switch TDS2. The timer portion of TDR2 begins to time only when TDR2 is de-energised. Once the timer portion of TDR2 has timed out, TDS2 closes. The timing function of TDR2 does not affect conventional relay contact points S3a or S3b, both actuated by TDR2. To this end second time delay relay TDR2 has three pairs of contact points. The first and second pairs of contact points are designated S3a and S3b and operate in the normal manner of any conventional "normally open" and "normally closed" relays; that is, when TDR2 is energised, normally open contact points S3a close and normally closed contact points S3b open. When TDR2 is de-energised contact points S3a return to their normally open state and contact points S3b return to their normally closed state. The third pair of contact points associated with TDR2 have been designated TDS2; it is only this pair of contact points which is associated with the timing function of TDR2; contact points S3a and S3b are not affected by the timing of TDR2. Contact points TDS2 are normally closed and open when TDR2 is energised. When TDR2 is de-energised, the timer associated with TDR2 begins to time and only after the timer is "timed out" does TDS2 close. The timing function to TDR2 is adjustable so the time TDS2 remains open after TDR2 has been de-energised can be varied.

S1b is a pair of normally open contact points actuated by relay R1; S1b provides a holding circuit for R1, HS1, HS2 and HS3 are hand-actuated switches which are respectively normally open, normally closed and normally closed. These three switches allow hand control of TDR1 and C1. TDR1 is an "on time delay relay" with timing starting when TDR1 is energised. TDR1 opens normally closed pair of contact points TDS1 when it has timed out. Once de-energised, TDR1 allows points TDS1 to r turn to their normally closed position. Coil C1 controls air cylinder 76. When C1 is energised, air is supplied to cylinder 76 by opening a conventional valve thereby allowing compressed air to enter cylinder 76, causing a downward stroke of reciprocating plunger 44 and vertical rod 78. When C1 is de-energised, reciprocating plunger 44 and vertical rod 78 are returned to their starting position, where the downward stroke begins.

S2a and S2b respectively are normally closed and normally open pairs of contact points actuated by relay R2. L3 and L4 are the lower and upper limit switches actuated by low and upper adjustable cam means 80 and 82 respectively. L3 is normally open and is closed only during contact with the cam 80, this contact defines the maximum downward travel of plunger 44. L4 is normally closed and is opened by the cam 82 at the maximum upward travel of plunger 44.

HS4 is a hand switch with four sets of contact points, two of which are normally opened and two of which are normally closed. Hand actuation of HS4 changes operation of the feeding system from the manual to the automatic mode. HS6 is a hand switch for manual operation of hydraulic motor 42 which powers conveyor 22. Coil C2 when energised actuates a conventional hydraulic valve which controls the flow of hydraulic fluid to hydraulic motor 42. HS5 is a normally open hand actuated switch.

The preferred apparatus provides a closed system for closely controlled automatic feeding of friction material from a remote closed agitator into a means for plasticizing or extruding the material.

A key feature of the preferred apparatus is its characteristic of automatically feeding the friction material at a controlled rate to the plasticizing screw 52 while keeping the friction material confined so that it will not escape to contaminate the surrounding atmosphere and making the work area unsuitable for workers.

Initially, the premixed material in agitator 10 is fed into the conveyor 22 through the duct 38. As the horizontal shaft 28 with the fingers 30 rotates, it keeps the material in the agitator agitated thereby keeping the mixture homogeneous and preventing the material from bridging over the lower end of the feed conveyor.

The flexible conveyor 22 is driven by the hydraulic motor 42 to feed the friction material from the agitator 10 along a closed spiral path into the feed hopper 48. As will be described, the operation of the conveyor 22 is closely controlled in order to ensure a correct feed rate into the hopper 48.

Once the friction material has been fed into the feed hopper 48, it is then force-fed through orifice 49 into the plasticizing screw 52. This feeding is accomplished by reciprocating the plunger 44 by means of the air cylinder 76. Since the friction material is not free-flowing, there is a tendency for the material in feed hopper 48 to form a bridge across the orifice 49, thereby preventing the screw 52 from receiving any material. One function of the reciprocating plunger 44 is therefore to break up any bridging of material which occurs above orifice 49 and to stuff material down orifice 49 into the plasticizing screw 52. In this way, there is assurance that plasticizing screw 52 is receiving the friction or material at least as fast as plasticizing screw 52 can transport the material from the orifice 49 towards the preform cup 70.

For the reciprocating plunger 44 to function properly, the rate at which friction material is fed into feed hopper 48 must be precisely controlled and must be substantially equal to the rate at which plasticizing screw 52 removes friction material from orifice 49. If the amount of material fed into the feed hopper 48 is too small, too little material will move through the plasticizing screw barrel 54, causing the material in barrel 54 to become too hot. This is unacceptable since the temperature of the material reaching preform cup 70 must be controlled within close limits. If the temp rature is too high, too much curing of the thermoset resin portion of the material will occur, making the subsequent moulding in press 18 impossible. If too much material is fed into the feed hopper 48, the material will build up therein because plasticizing screw 52 will be unable to remove it quickly enough from orifice 49. This also is unacceptable, because the friction material will not flow properly when such build-up begins and the reciprocating plunger 44 will simply make a hole through the builtup material, an effect known as "rat-holing". The result again is that the plasticizing screw 52 is starved of material with consequential overheating.

For controlling the rate of feed of friction material to the plasticizing screw, three controls are provided. The first control is a valve for controlling the rate of driving fluid to the hydraulic motor 42. This flow control is conventional, is preferably hand operated and is not shown in the drawings. It is preset for a given type of material which is fed into feed hopper 48. Normally once the proper setting is determined for this flow control depending on the friction material, the flow control need not be furth r adjusted. This flow control therefore provides an overall manual control for setting th rate of feed of the friction mat rial into the f ed hopper 48. However, because of the nature of the feed material, i.e. its high bulk, a sufficiently constant feed rate of material into the feed hopper 48 is not obtainable. Accordingly, a second control is needed.

This second control is a time control consisting of first time delay relay TDR1 controlling coil C2 which activates a conventional input electrical circuit, not shown, which serves to actuate a conventional hydraulic valve, not shown, which controls flow of drive fluid to the hydraulic motor 42. First time delay relay TDR1 is actuated when reciprocating plunger 44 starts its downward stroke. Time delay relay TDR1 can be preset to operate after a predetermined time interval after which TDR1 is said to "time-out". When TDR1 times out, its open TDS1 in the input circuit to coil C2 thereby closing the hydraulic valve, shutting off the drive fluid to the hydraulic motor 42 thereby interrupting operation of the flexible conveyor 22 and halting feeding of friction material into feed hopper 48. TDR1 is preferably adjustable so that it can be set to a suitable time whereupon it will stop any overfeeding of friction material into the feed hopper 48.

The third control used for control of feed rate of the friction material to the plasticizing screw 52 is level sensing switch 92 to sense the level of friction material in the feed hopper 48. Any suitable sensing means may be used to sense this material level for example, that shown in U.S. Patent No. 3,225,963. Other suitable level sensing means include mechanically operated switches wherein a mechanical arm is deflected when the material in feed hopper 48 reaches a predetermined level. Whatever level sensing means is used, it is connected to electrical circuitry for control of the drive fluid to the hydraulic motor 42. So long as the level of material is maintained below the predetermined level reciprocating plunger 44 will continue to operate to stuff the friction material through the orifice 49 into the plasticizing screw 52.

During the normal operation, plasticizing screw 52 rotates only while a preform is being formed into preform cup 70. Reciprocating plunger 44 operates only while plasticizing screw 52 is rotating. This operation of reciprocating plunger 44 in conjunction with plasticizing screw 52 is controlled by step switch circuitry which controls the sequence of making preforms. A preferred step switch circuitry and its operation is described in U.S. Patent No. 3,661,485. The lectrical power supply controlling the feed of air to air cylinder 76, the feed of electricity to motor 32 and the

feed of drive fluid to hydraulic motor 42 is preferably connected in parallel with th source of electrical power controlling operation of plasticizing screw motor 50. Thus, only when plasticizing screw 50 is operative and rotating will friction material be fed from the agitator 10 through flexible conveyor 22 into feed hopper 48 and through orifice 49 into the plasticizing screw 52.

The level sensing means 92 in feed hopper 48 is a safety device which normally functions only in the event of a failure of TDR1. During normal operation, TDR1 alone serves to control the operation of the air cylinder 76, and the reciprocating plunger 44.

During normal automatic operation, the operation of TDR1 is as follows: plasticizing screw 52 commences rotation thereby to feed the friction material in a partially plasticized condition into the preform cup 70. During this process the air cylinder 76 is actuated to initiate downward travel of reciprocating plunger 44 and rod 78. Upper cam 80, adjustably affixed to the rod 78, moves downward thereby allowing top limit switch L4 to close, which in turn triggers TDR1 by de-energising R2 thereby allowing S2a to return to the normally closed state. This actuates the timer associated with TDR1. When reciprocating plunger 44 reaches the bottom extremity of its travel, the lower cam 82 contacts bottom limit switch L3 which energizes R2, thereby opening S2a and de-energizing C1 and TDR1. This reverses the air flow into the cylinder 76, thus causing reciprocating plunger 44 to rise to its upper extremity, where another reciprocation of reciprocating plunger 44 is begun. Note that if TDR1 times out, the reciprocating plunger 44 continues its downward travel, i.e. it does not stop upon completion of the preset time. The function of TDR1 is to control the operation of the hydraulic motor 42, which drives flexible screw 40, not to control the operation of the reciprocating plunger 44. Either of two events makes the piston in cylinder 76 travel to its upper extremity whereupon it is ready to begin another downward stroke; these two events are (1) stopping the plasticizing screw 52, which means that preform cup 70 is full or (2) allowing reciprocating plunger 44 to reach a lower extremity of travel whereupon the lower cam 82 actuates the bottom limit switch L3. If TDR1 times out during the downward stroke of the plunger 44, this signifies that the friction material is already tightly packed below the plunger 44 thereby filling the orific 49 and in contact with plasticizing screw 52. If plunger 44 is still in contact with friction material in the feed hopper 48 when TDR1 times out, the plunger 44 does not stop because plasticizing screw 52 continues to rotate, thereby continuously removing friction material from orifice 49; accordingly the plunger 44 continues to travel downwardly. If the plasticizing screw 52 stops rotating due to shut off of electrical power, the consequent de-energizing of coil C1 causes the plunger 44 to return to its extreme top position ready for another downward stroke upon reconnection of electrical power.

Reference is again made to Figure 6. When the feeding mechanism is operated manually, power is supplied through line P3. Actuation of HS1 energizes C1, thereby causing reciprocation of the piston in air cylinder 76 with consequent reciprocation of plunger 44 and actuation of TDR1. However, this actuation of TDR1 need have no effect on operation of the feeding mechanism since TDS1 may be effectively bypassed by actuation of HS6. Assuming TDS2 is in its normally closed position, actuation of HS6 will actuate C2 which initiates operation of hydraulic motor 42, thereby providing feed of friction material to the feed hopper 48. Similarly, manual actuation of HS5 energizes electric motor 32 thereby rotating shaft 28, assuming that L5 is in its closed position, indicating that the cover interlock on agitator 10 is operative.

Note that when operating in the manual mode, level sensing means 92 and TDR2 are both operative from power supplied through line P1. This means that even in the manual operating mode, if feed hopper 48 becomes too full of material, TDR2 will be actuated, thereby opening TDS2 and thereby stopping operation of hydraulic motor 42 halting feeding of friction material into feed hopper 48. Level sensing means 92 and TDR2 operate in the same fashion as when the feeding mechanism is operating in the automatic mode since power is always supplied through line P1 no matter which mode of operation is being used.

Reference is again made to Figure 6 for consideration of the operation of the circuit when the feeding apparatus is operating in the preferred automatic feed mode. HS4 is a selector switch which the operator uses to select either the automatic or manual mode of operation. As shown in Figure 6, HS4 is in position for manual operation. While operating in the automatic mode, HS4 is actuated, from the state shown in Figure 6, thereby making the circuits in reference lines 11 and 13 and breaking the circuits in reference lines 12 and 14. Ref rring to reference lin s 1, 2, 3 and 4, so long as the level of friction material in feed hopper 48 is below that at which L1 is closed, L2 will

remain closed, thereby energizing R1 which in turn causes S1a and S1b to be actuated from their normally open positions to closed positions. Upon the material in feed hopper 48 reaching the maximum allowable level, L1 will close, thereby opening L2. R1 will remain energized due to closed S1b. Once L1 closes, TDR2 is energized since S1a is closed. Upon TDR2 being energized, S3a closes, S3b opens and TDS2 opens thereby halting feed of friction material by de-energizing coil C2 which controls hydraulic motor 42. TDS2 remains open, thereby preventing the feeding of friction material, until TDR2 has been de-energized, by the level of material in feed hopper 48 dropping thereby deactuating L2, and the timer portion of TDR2 has timed out. Both S3a and S3b respectively close and open immediately upon TDR2 energizing since S3a and S3b are not connected to the timing function of TDR2. Once the level of friction material in feed hopper 48 has dropped below the maximum allowable level, L1 opens and L2 closes, thereby energizing R1. This closes S1b thereby providing a hold circuit for R1. Upon L1 opening, TDR2 is no longer energized and S3b returns to its normally losed position. TDS2 returns to its normally closed state after the timing function of TDR2 has finished.

TDR1 begins to time when it is energized with C1 which actuates a valve in an air line to cylinder 76. When C1 is energized, the piston in cylinder 76 begins it downward stroke, thereby causing plunger 44 and rod 78 to begin the downward portion of a reciprocation. Accordingly, TDR1 begins to time when plunger 44 starts down. S2a is normally closed and is actuated by R2. When C1 is actuated and the piston in cylinder 76 begins its downward travel, R2 is not energized and S2a is in its normally closed position. L4 is in its normally closed position, having closed immediately upon upper cam 82 moving away from L4 upon the downward movement of the rod 78. Once the piston in cylinder 76 starts downward, it continues downward until lower cam 80 closes normally open L3. This energiz s R2 thereby opening S2a and closing S2b. Closure of S2b provides a holding circuit which maintains R2 in the energized state. When S2a opens, C1 is deenergized thereby causing piston in cylinder 76 to travel upwardly from its extreme downward position. TDR1 is also de-energized. The piston in cylinder 76 continues to move upwardly until upper cam 82 opens normally closed L4. This de-energizes R2, thereby allowing S2a and S2b to return to their normally closed and normally open states respectively. When S2a closes, C1 is energized and the piston begins another downward stroke. Thus, once drive motor 50 for plasticizing screw 52 is actuated and HS4 is in position for automatic operation, the piston in cylinder 76 will begin to reciprocate.

Clearly, each time the piston in cylinder 76 reciprocates upon actuation of C1, TDR1 is also energized and begins to time. When TDR1 times out, normally closed TDS1 opens thereby de-energizing C2. This stops hydraulic motor 42, halting feeding of friction material into the feed hopper 48. TDS1 closed when TDR1 is energized again at the start of another downward stroke of the plunger. TDS2 opens upon TDR2 being energized, remains open even while TDR2 is timing after being de-energized and closes only when TDR2 has timed out. As noted above, TDR2 is only actuated when the level sensor 92 senses that friction material has accumulated to the maximum allowable level in the feed hopper 48. Thus, TDR1 and TDR2 operate together to actuate C2 and control hydraulic motor 42.

This operaton is as follows. TDR1 is energized and begins to time each time plunger 44 initiates a downward stroke. If the downward stroke of plunger 44 is completed before TDR1 times out, TDR1 will initiate timing upon the start of the next downward stroke of plunger 44. Energizing TDR1 on a second downward stroke of plunger 44 before TDR1 has timed out from the previous stroke of plunger 44 will cause TDS1 to remain closed. In this condition C2 will remain energized and hydraulic motor 42 will continue to operate screw 40 thereby continuing the feed of friction material into feed hopper 48. Once feed hopper 48 becomes sufficiently full of material that a downward stroke of plunger 44 is impeded by the presence of the material, to the extent that a full reciprocation of plunger 44 exceeds the time to which the timer portion of TDR1 has been set, TDS1 will open thereby halting feed of material into feed hopper 48. In such case, TDS1 will remain open until TDR1 is again energized when plunger 44 has completed its downward stroke and has returned to its extreme upward position. Thus, when so much material has been fed into feed hopper 48 that plunger 44 requires an extended time to complete a single reciprocation, the feed of material into hopper 48 will be halted until plunger 44 has begun another downward reciprocation, thereby stuffing more material through orifice 49.

In the event the level of material in hopper 48 exceeds the maximum allowable level, thereby closing normally open L1 and energizing TDR2, TDS2 is immediat ly opened, thereby de-energizing C2, stopping

hydraulic motor 42 and halting the feed of friction mat rial into hopper 48. TDS2 remains open so long as TDR2 is energized, and for the period after TDR2 is de-energized, until TDR2 times out. Only after TDR2 times out will TDS2 close, thereby energizing C2, operating hydraulic motor 42 and thereby feeding more friction material into hopper 48. TDR2 does not start to time until it is de-energized by L1 opening due to a drop in the level of friction material in hopper 48. The time interval to which the timer portion of TDR2 is normally set is sufficiently long to allow plunger 44 to perform at least a major portion of one reciprocation. Thus TDS2 once open will not close until the level of friction material in hopper 48 has dropped below the maximum allowable high level and plunger 44 has forced some of the friction material in hopper 48 through orifice 49 into the plasticizing screw 52. In this way TDR1 and TDR2, by actuating TDS1 and TDS2 respectively, prevent the level of friction material in hopper 48 from exceeding the maximum allowable level at which rat holing starts to occur and allow plunger 44 to stuff some material through orifice 49 before hopper 48 is again completely refilled. This is the process of "starve feeding" without which plunger 44 cannot successfully feed friction material through orifice 49 into contact with plasticizing screw 52.

The electric motor 32 which drives shaft 28 runs continuously when the feeding apparatus of the present invention is operating in the automatic mode, so long as normally open L5 is closed by a cover on agitator 10. Thus, the material in agitator 10 is continuously agitated and mixed without regard to whether any material is being removed from agitator 10 by means of flexible screw 40.

With reference to Figure 1 the function of the conveyor 22 is primarily to convey material from the agitator to the feed hopper 48. However, inevitably some compaction or compression of the friction material will occur. Further compression of the mixture is performed by successive reciprocations of plunger 44 which stuffs and compresses increments of the mixed friction material through orifice 49 into the plasticizing screw 52. Rotation of plasticizing screw 52 performs the final portion of the compression process which is necessary before it finally reaches preform cup 70 in which it is finally shaped and divided into substantially equal preform shapes by the guillotine which operates between the preform cup 70 and the extruder 54. Heat for partially plasticizing the mixed friction material is generated by frictional energy supplied by the plasticizing screw 52 with any additional r quired heat being supplied by heaters in th housing 54. Those heaters may be electrical heaters or may comprise conduits for the circulation of a heated liquid through the screw housing 54. A typical temperature of the partially plasticized material as it exits from housing 54 into the preform cup 70 is about 240°F.

The amount of partially plasticized mixture extruded into the preform cup 70 and separated from the rest of the extruded mixture by the guillotine is dependent on the length of time during which the screw 52 is in operation. It is not necessary for the partially plasticized mixture to fill the preform cup, as long as the amount is sufficient to fill the mould in the following step. For a further discussion of the control of the amount of partially plasticized mixture extruded into the preform cup reference should be made to U.S. Patent No. 3,661,485.

The degree of plasticization of the mixed friction material which is extruded into preform cup 70 is adjustably controllable by varying the annular spacing between a conical leading edge of plasticizing screw 52 and tapered front wall of plasticizing screw-housing 54 which is adjacent the orifice through which the partially plasticized material exits into preform cup 70, as disclosed in said U.S. Patent No. 3,661,485. It will be understood that the forming of preforms is an intermittent, discrete procedure and that plasticizing screw 52 is not run continuously but is run only as required to form a preform in preform cup 70. Accordingly, the progressive movement of the mixed friction material along the feed conveyor 22 and through orifice 49 is intermittent rather than continuous.

The final moulding of the preforms in the press 18 must be performed reasonably quickly whilst the preform is still in its partially plasticized condition. Ideally, moulding is performed with a few minutes after a preform is formed. Typical mould cycle times are from 60 to 180 seconds at temperatures of from 300°F to 320°F. The pressure applied by moulding press 18 to the preforms as they are moulded ranges from 1750 psi to about 2250 psi.

The preforms may be moulded singly or in batches of 6 or more at a time using appropriate mould halves secured to the stationary and movable platens 58 and 60 of the press 18. The operation and constuction of the press is, however, conventional, and n ed not be describ d in detail.

Following moulding in th press 18 the moulded articles are ejected from the moulding press 18 by suitable means at the

termination of each cycle of the moulding press. The moulded articles fall through duct 64 and are caught in a suitable container for further processing, for example, feeding to a curing oven for a final cure of the thermosetting resin binder.

In conclusion, it should be noted that the apparatus described above and particularly illustrated in the accompanying drawings is the subject of our copending application No. 30412/76 (Serial No. 1,517,852).

WHAT WE CLAIM IS:—

1. A method of producing moulded brake pads and other articles comprising a heat dissipating friction material embedded in a thermoset resin binder, which comprises:

(i) premixing the friction material in a dry state with a thermosetting resin to form a dry, mouldable mixture;

(ii) mechanically conveying the premixed materials along a first enclosed path into an enclosed hopper;

(iii) feeding the premixed materials along a second enclosed path from said hopper into a plasticizing screw of a preform moulding machine;

(iv) delivering the mixture partially plasticized by said screw, into one or a succession of preform moulds;

(v) severing each preform from the remainder of the partially plasticized material; and

(vi) compression moulding the preforms to the desired shape.

2. A method according to claim 1, wherein the screw plasticizer is operated intermittently and the premixed material is moved along said closed paths only during operation of the screw plasticizer.

3. A method according to claim 1 or 2, wherein the premixed material is forced from said hopper into the plasticizer by a reciprocating plunger.

4. A method according to claim 3, wherein the f ed of material into the hopper is interrupted whenever th duration of the feed stroke of said reciprocating plunger which forces the mixture from the hopper exceeds a predetermined value.

5. A method according to claim 3 or 4, wherein the level of material in the feed hopper is monitored and the feed of material into the hopper interrupted whenever the material therein exceeds a predetermined level.

6. A method according to claim 5, wherein, after interruption of said feed to the hopper following an increase in the amount of material in the hopper to above said predetermined level, the feed to the hopper is restarted only after a predetermined time interval has elapsed following the fall of the material back to below said predetermined level.

7. A method according to any one of claims 3—6, wherein the premixed material is fed to the feed hopper from a storage vessel in which the premixed material is maintained substantially continuously in an agitated state.

8. A method according to any one of the preceding claims, as applied to the moulding of brake pads or other articles of resin bonded asbestos fibre.

9. A method according to claim 1, substantially as hereinbefore described.

10. Moulded articles of resin bonded friction material when produced by a method claimed in any one of the preceding claims.

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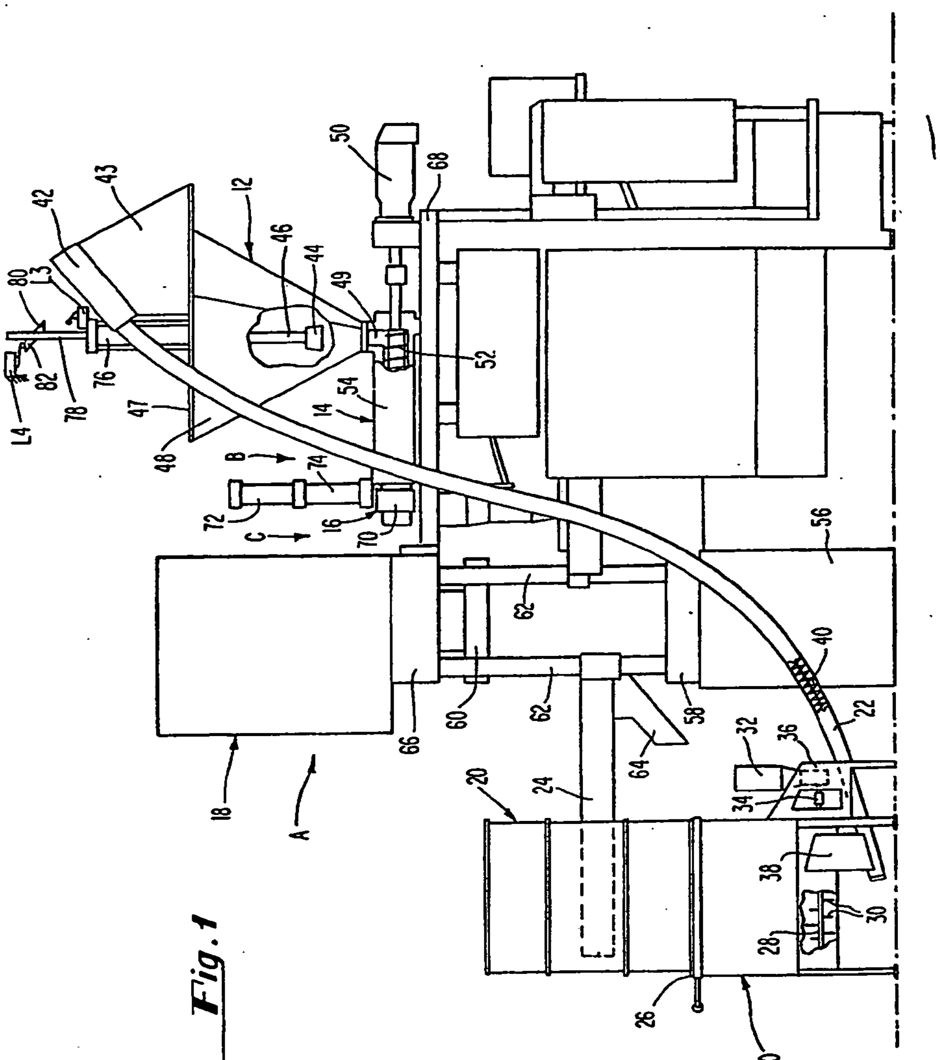
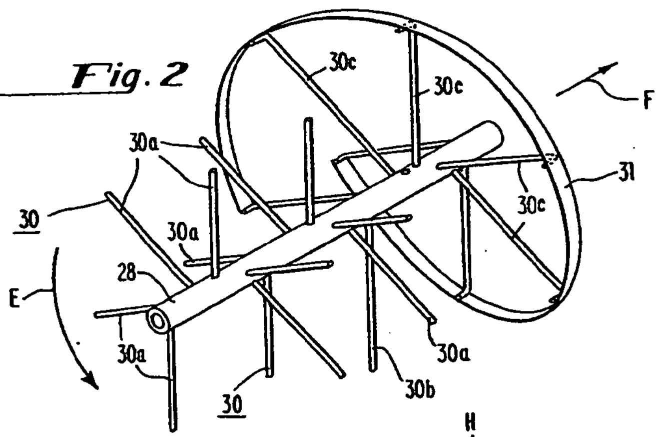


Fig.1

Fig. 2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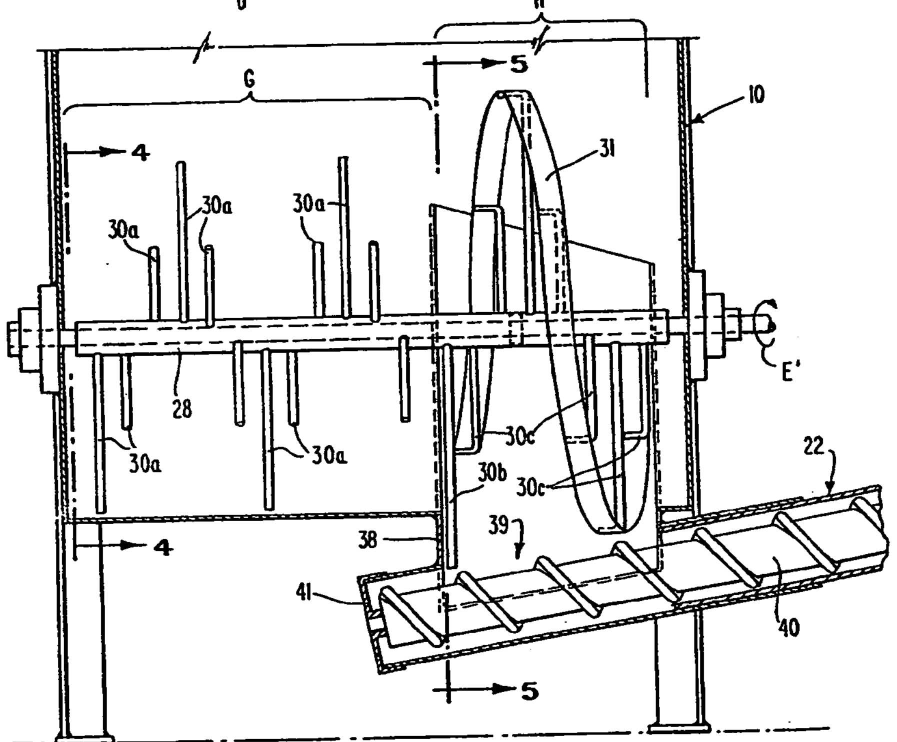
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Fig. 3

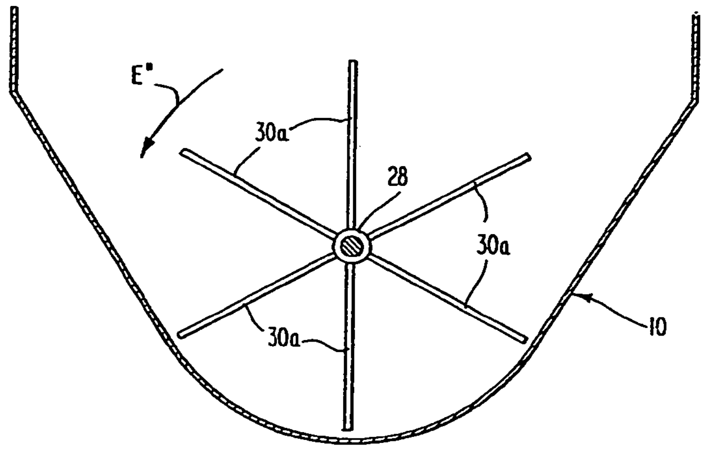

Fig. 4

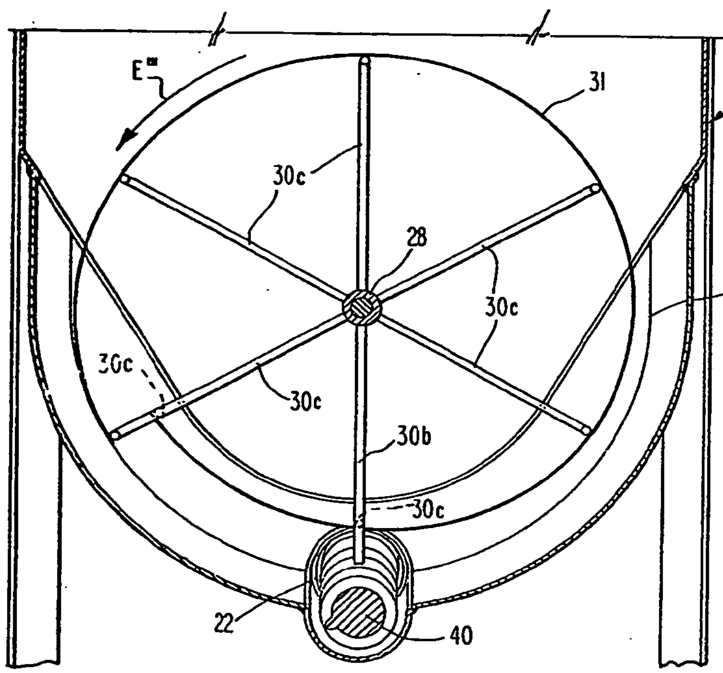

Fig. 5

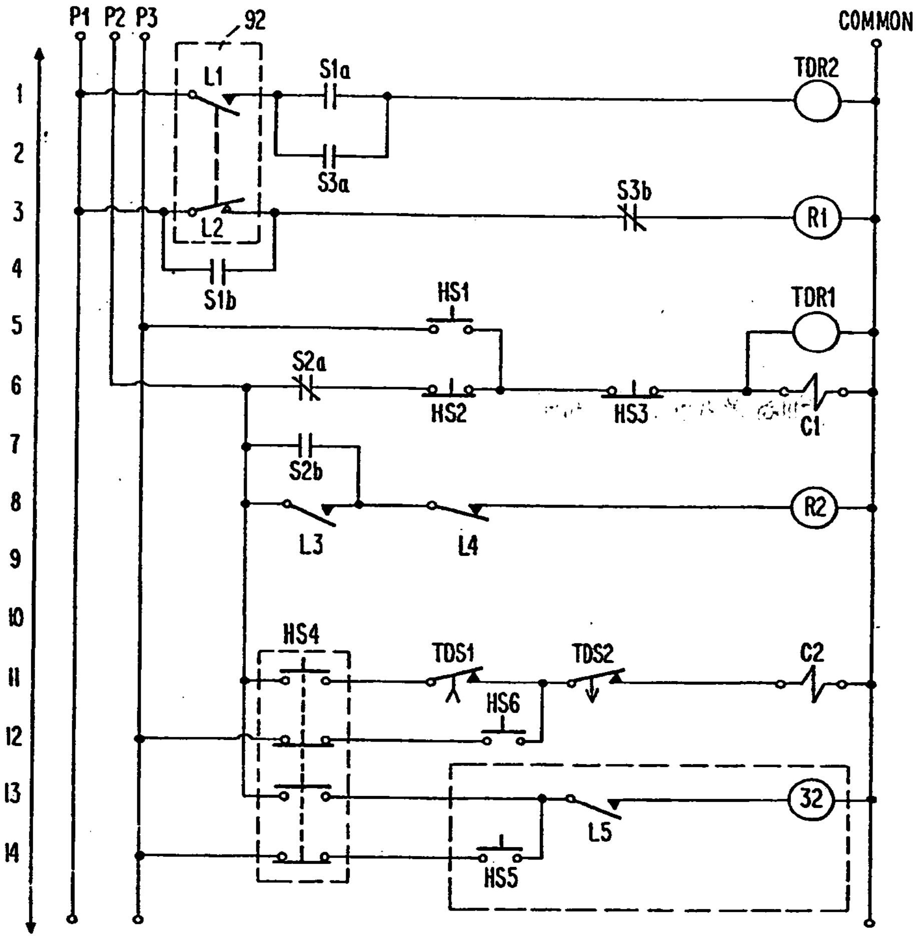
P1 P2 P3
92
COMMON
1
2
3
4
5
6
7
8
9
10
11
12
13
14
L1
S1a
S3a
TDR2
L2
S3b
R1
S1b
HS1
TDR1
S2a
HS2
HS3
C1
S2b
L3
L4
R2
HS4
TDS1
TDS2
C2
HS6
32
L5
HS5

Fig. 6